



Storage and Grain Quality Management

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**EXCELLENCE
CENTER**

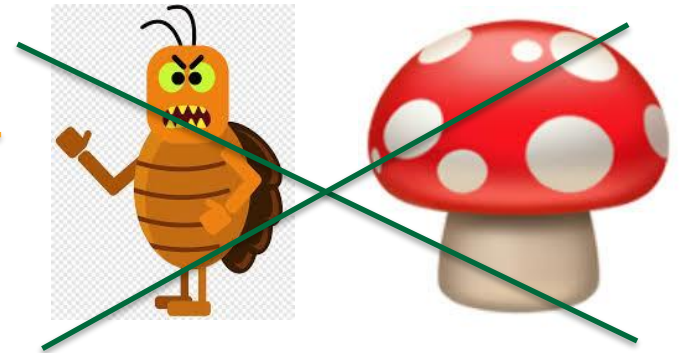
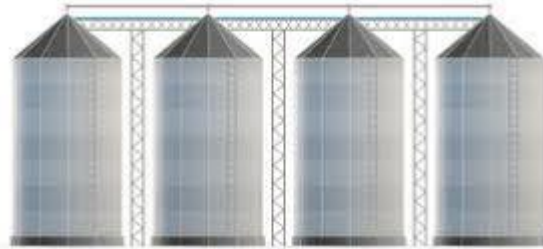
A  **SOY** program

Learning Objectives

- Understand the principles of grain and feed ingredient storage.
- Learn about the factors that affect grain and feed ingredient storage.
- Learn how to apply grain storage practices to maintain quality.

Importance of Having Good Storage Practices

- Maintain ingredients and finished feed quality. Reduce mold growth and mycotoxin (aflatoxin and ochratoxin).
- Reduce the risk of compaction of ingredients and feed in silos, hoppers and flat storage.
- Reduce shrink losses due to insect infestation or moisture loss.
- Avoid cross contamination of microorganisms and pathogens.



Why it is important to pay close attention to grain during storage in the tropics?



Grains and in particular corn from any origin are normally very susceptible to spoilage by mold when stored in semi-tropical and tropical climatic conditions.

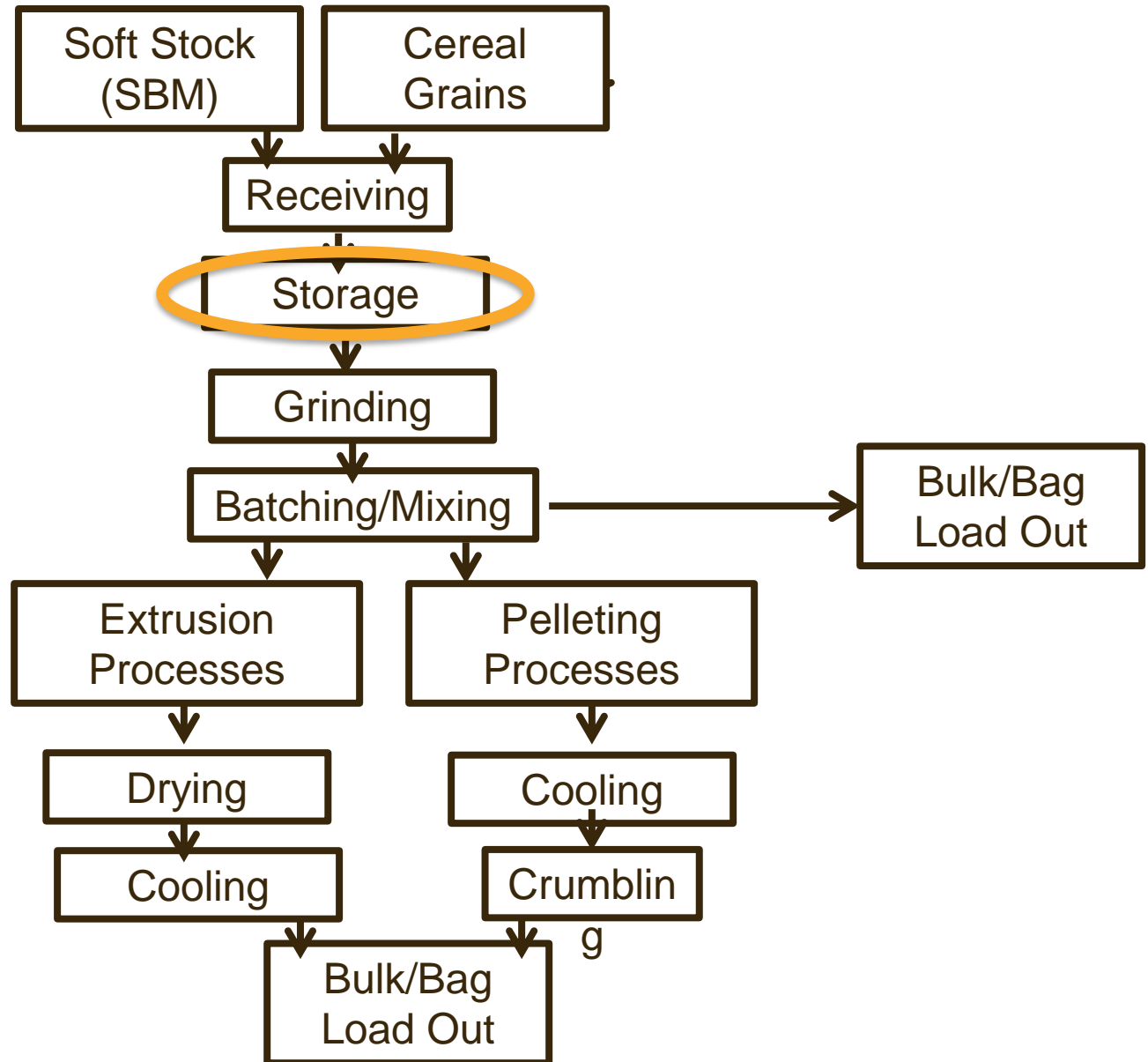


Tropical conditions: Are usual above 28°C & 65% RH (ideal for mold growth).



U.S. corn has that tendency, but its quality will also depend on many other factors like agronomic, handling, and storage.

Animal Feed Processing



Grain and Ambient Temperature

- Higher grain temperature will result in higher grain respiration.
- High grain temperature is an indicator of mold growth and insect activity.
- Grain that is warmer than the ambient temperature will result in deterioration in several weeks.

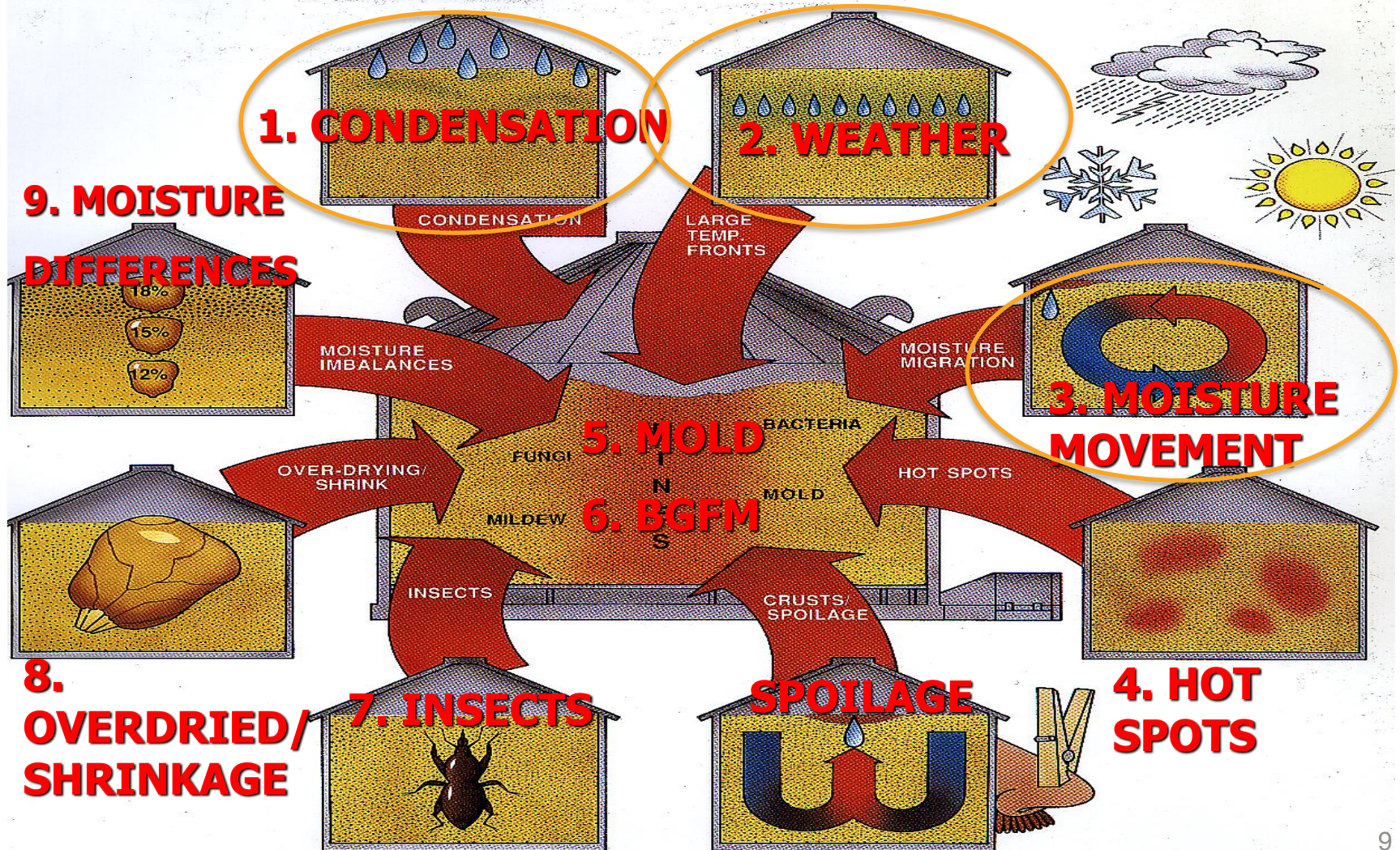
Relative Humidity

- Amount of water that is in vapor form in the air.
- Moisture content of the grain will equilibrate with the amount of water available in the air (Process called: Equilibrium Moisture Content).
- RH higher than 70% allows mold growth and higher insect activity.

Grain Moisture Content

- Amount of water inside the grain.
- It will equilibrate with the environment based on the ambient temperature and relative humidity (Equilibrium Moisture Content=EMC).
- Grain should be at “safe moisture contents” for proper storage.
- High moisture content will create high relative humidity in the grain mass allowing mold growth.

FACTORS THAT AFFECT GRAIN STORAGE



1. CONDENSATION

Several factors can cause it!

- Cool grain moving through warm and moist air will cause water to condense in the grain mass surface.
- Grain can absorb this moisture, but if it stays cool it will cause less negative effect.
- This effect can cause problems in electronic moisture content readers.

1. Condensation/2.Weather

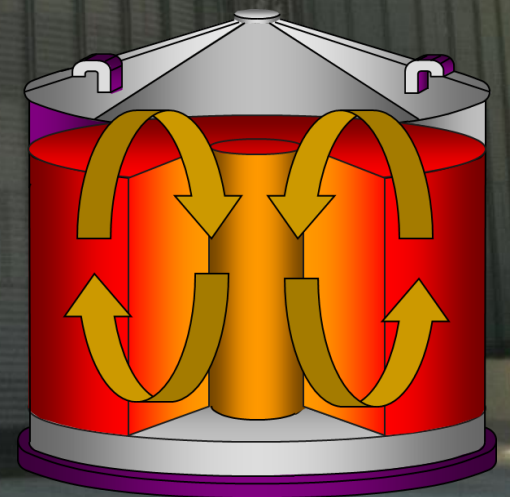
- **Weather changes:**
 - Effect of day (higher temperatures, lower relative humidity).
 - Effect of night (temperatures, higher relative humidity).
- **Internal movement of moisture and heat due to:**
 - Warm grain with cold walls of grain storage structure (shade effect).
 - Cool grain with warm & moist air (poorly managed aeration techniques).

3. MOISTURE AND HEAT MIGRATION

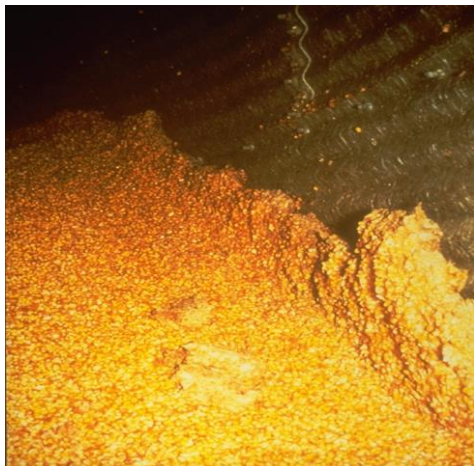
Warmer

Effect of the shade
(cooler side)

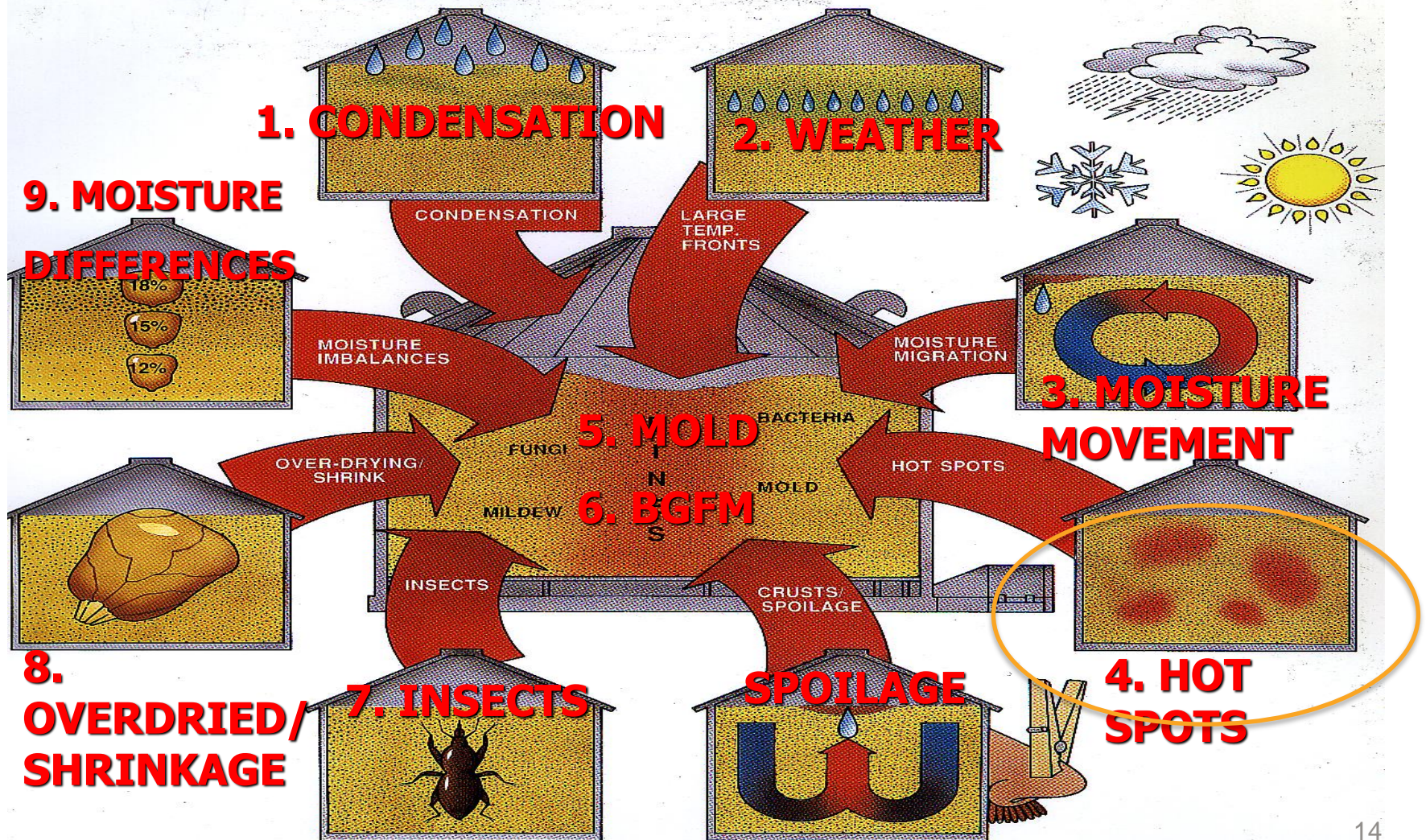
Cooler



Condensation during Storage



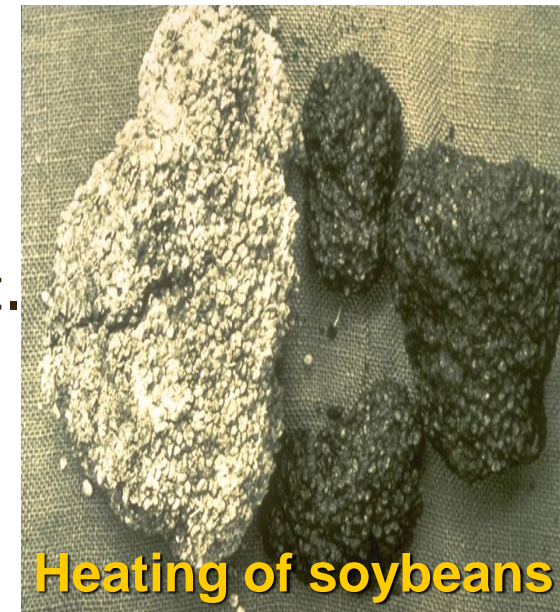
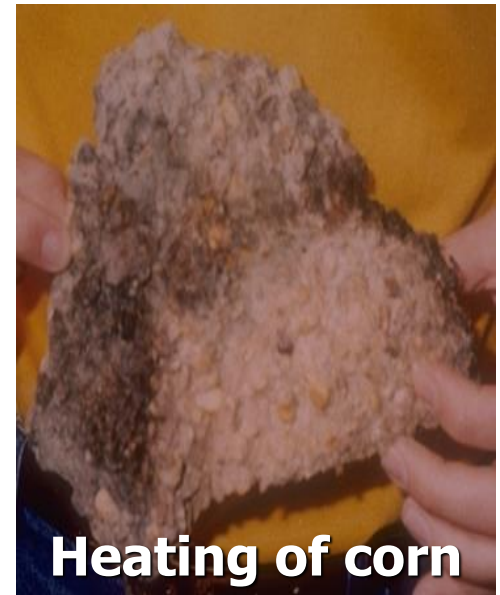
FACTORS THAT AFFECT GRAIN STORAGE



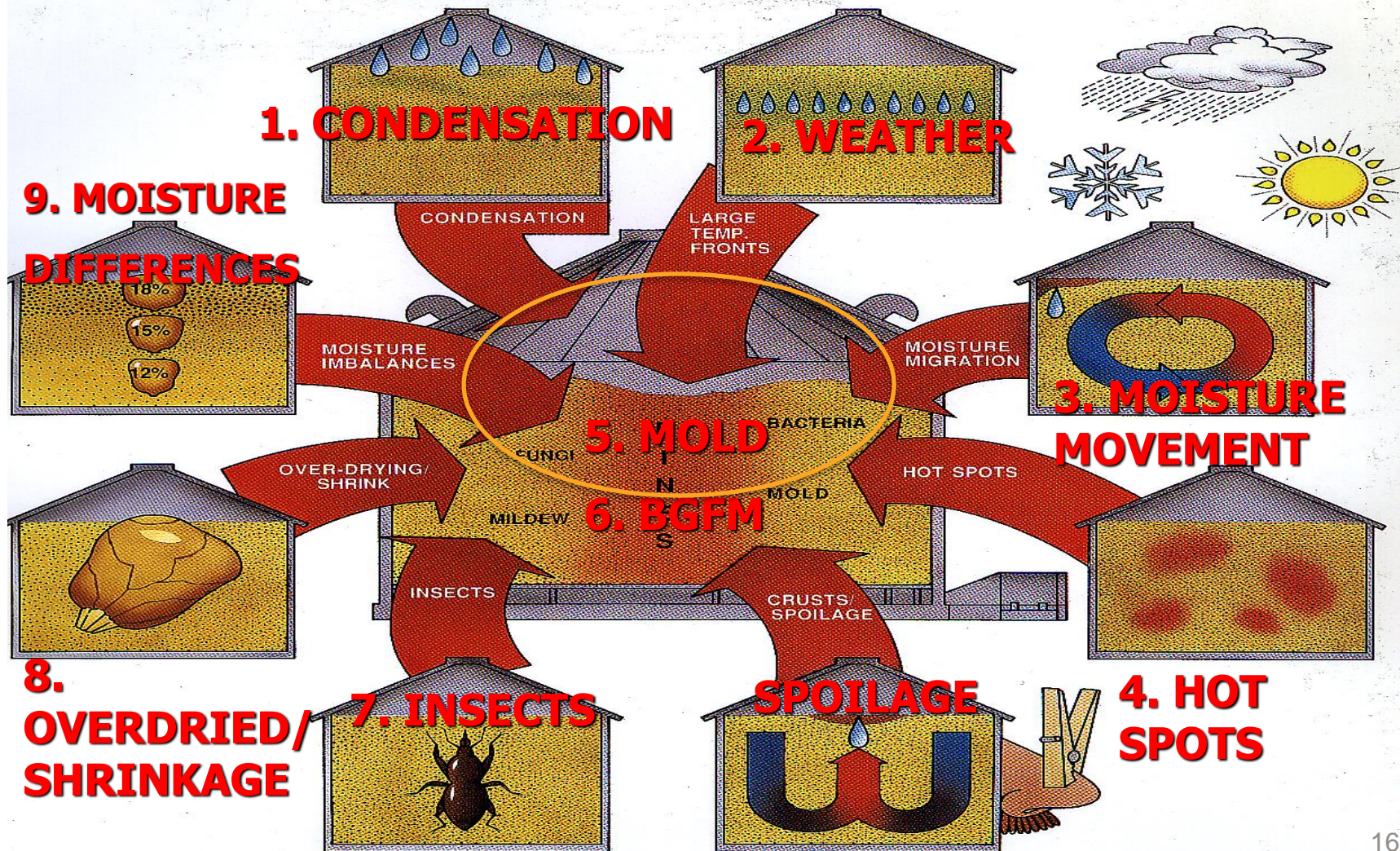
4. HOT SPOTS

CAUSE:

- Self-heating due to chemical & biological effects (bacteria, insect and mold present, and grain respiration).
- Carbohydrates in grain will be converted into heat and this energy will cause shrinkage.
- Grain is a good insulator.
- Will produce internal moisture movement.
- Can occur to soybeans!



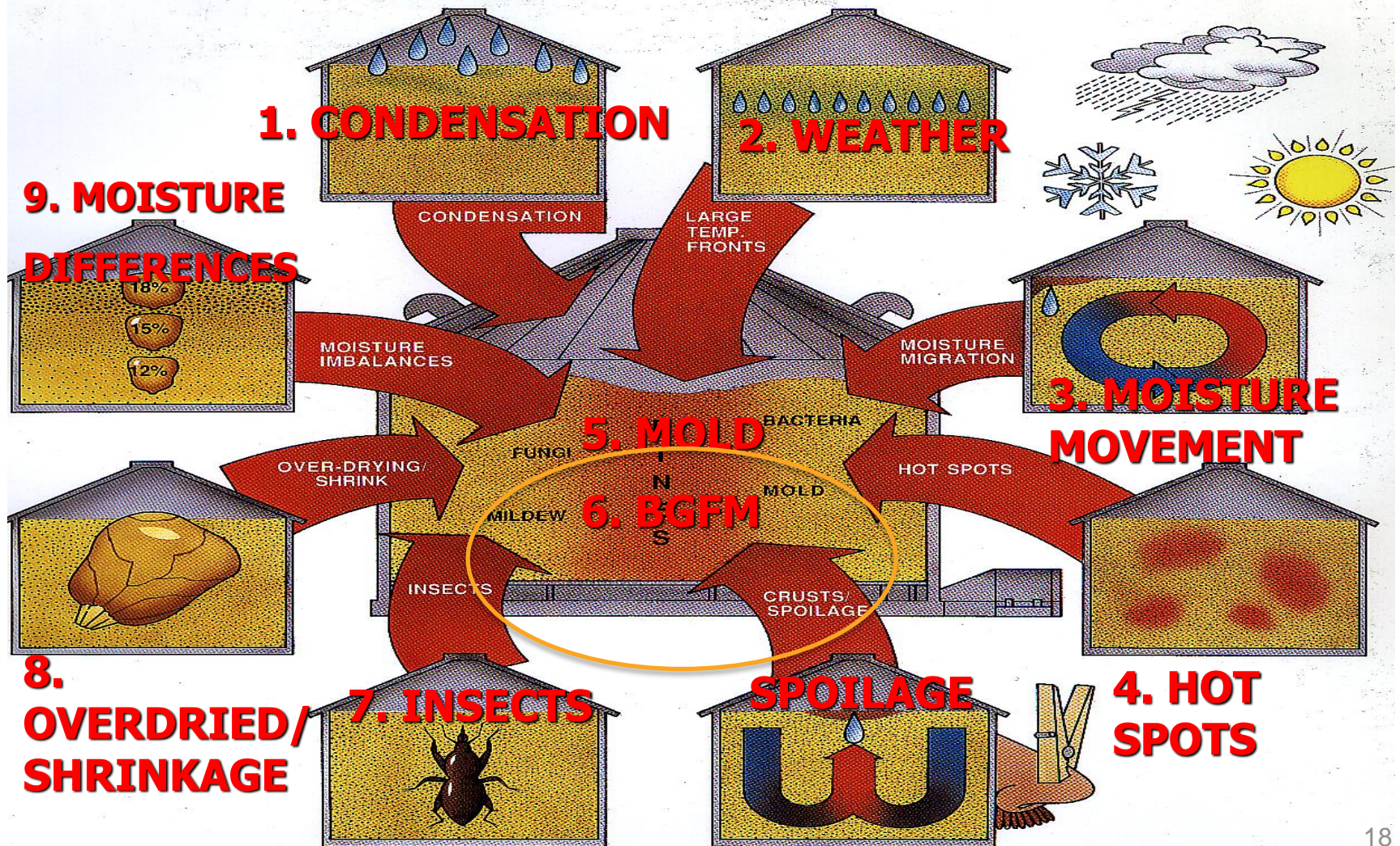
FACTORS THAT AFFECT GRAIN STORAGE



5. MOLDS

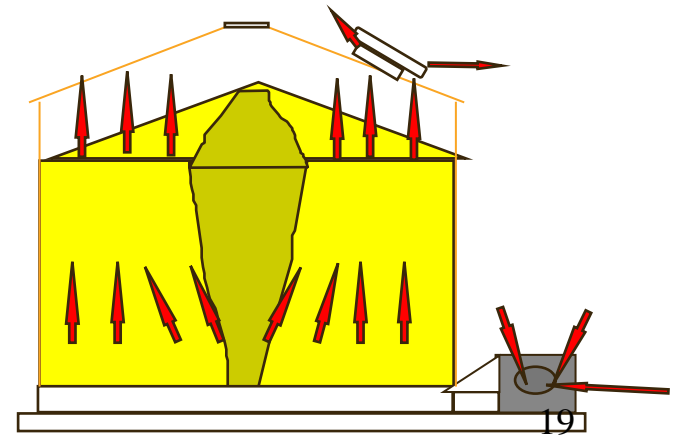
- **CANNOT BE AVOID!**
- Produces hot spots, spoilage and bad odors in grain.
- To reduce their growth, keep grain at safe moisture content levels (usually at least below 14.5 -15% for corn), avoid contact with grain that has different moisture contents.
- Mold can produce mycotoxins.

FACTORS THAT AFFECT GRAIN STORAGE

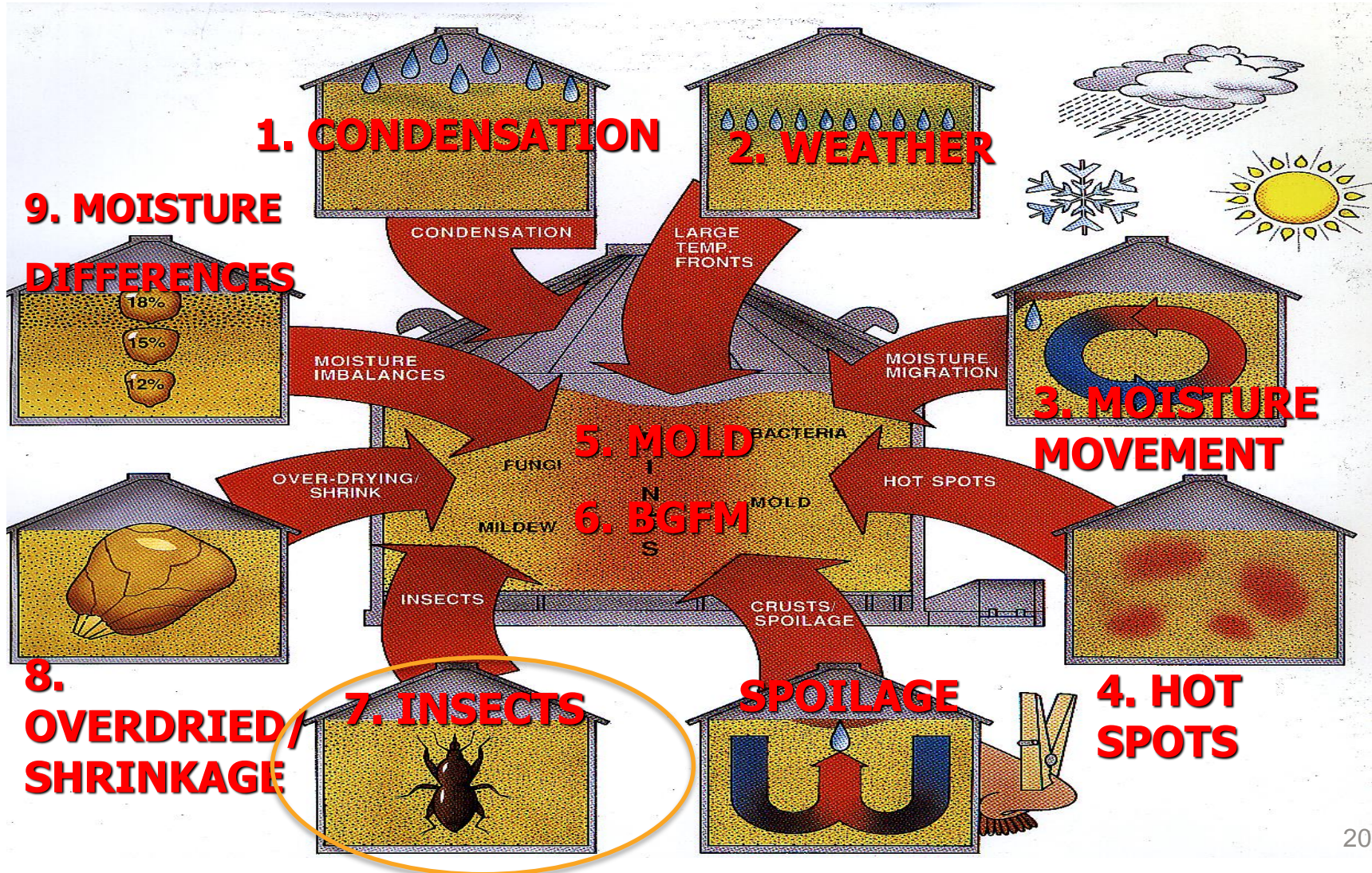


6. BROKEN GRAIN AND FOREIGN MATERIAL

- Problems:
 - Affects grain preservation
 - Accumulation of mold growth and insect feed (external feeders)
 - Concentration of mycotoxins
 - Affects airflow for aeration



FACTORS THAT AFFECT GRAIN STORAGE



7. INSECTS

- **CAN BE AVOIDED!**

Growth (Optimal temperature between 25 to 32 °C and relative humidity above 65%).

They can be eradicated with pest control programs (*IPM*) and fumigation.

Effect of Ambient Temperature on Insects

(Source: Fields 1992)

TEMPERATURE (°C)	EFFECT
>50°C	Death in minutes
>35°C	Reduced growth
25-32°C	Optimal growth
19-25°C	Almost optimal
5-15.5°C	Death in several days
-17.7°C	Death in minutes

8. OVER DRYING-SHRINKAGE

- Over-drying caused by high temperature drying which will cause breakage and produce BGFM.
- Shrinkage is the reduction of dry material due to loss by production of BGFM and grain respiration.

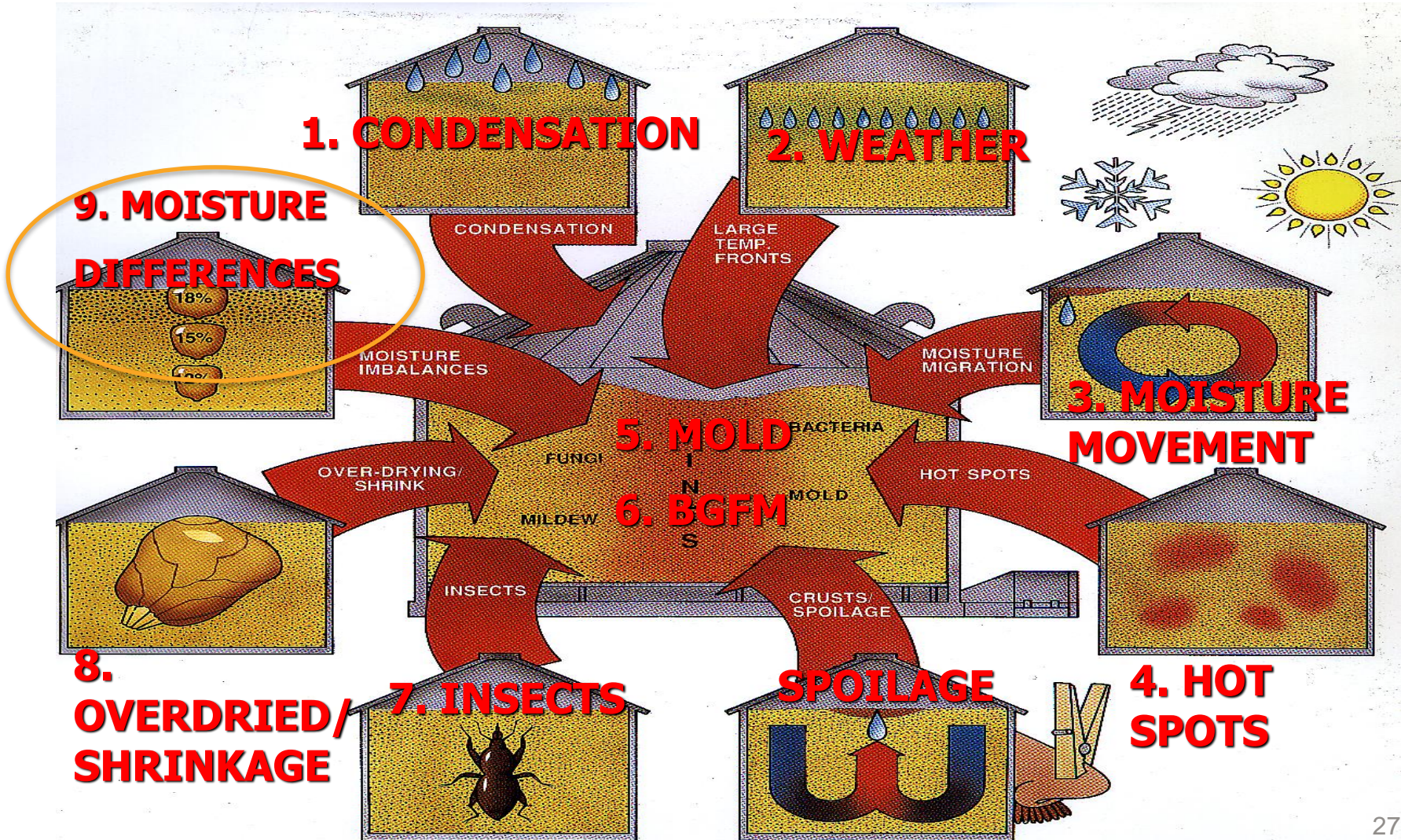
8. SHRINKAGE

- Can be produce by grain respiration (biological material) that can cause:
 - Inventory losses
 - Affect feed nutrition and processing
 - Minimized by:
 - Preventing and controlling factors causing it through proper silo management.

GRAIN RESPIRATION

- Increases with higher temperature and relative humidity.
- It is reduced when grain has a lower moisture content.
- Usually nothing can be done.

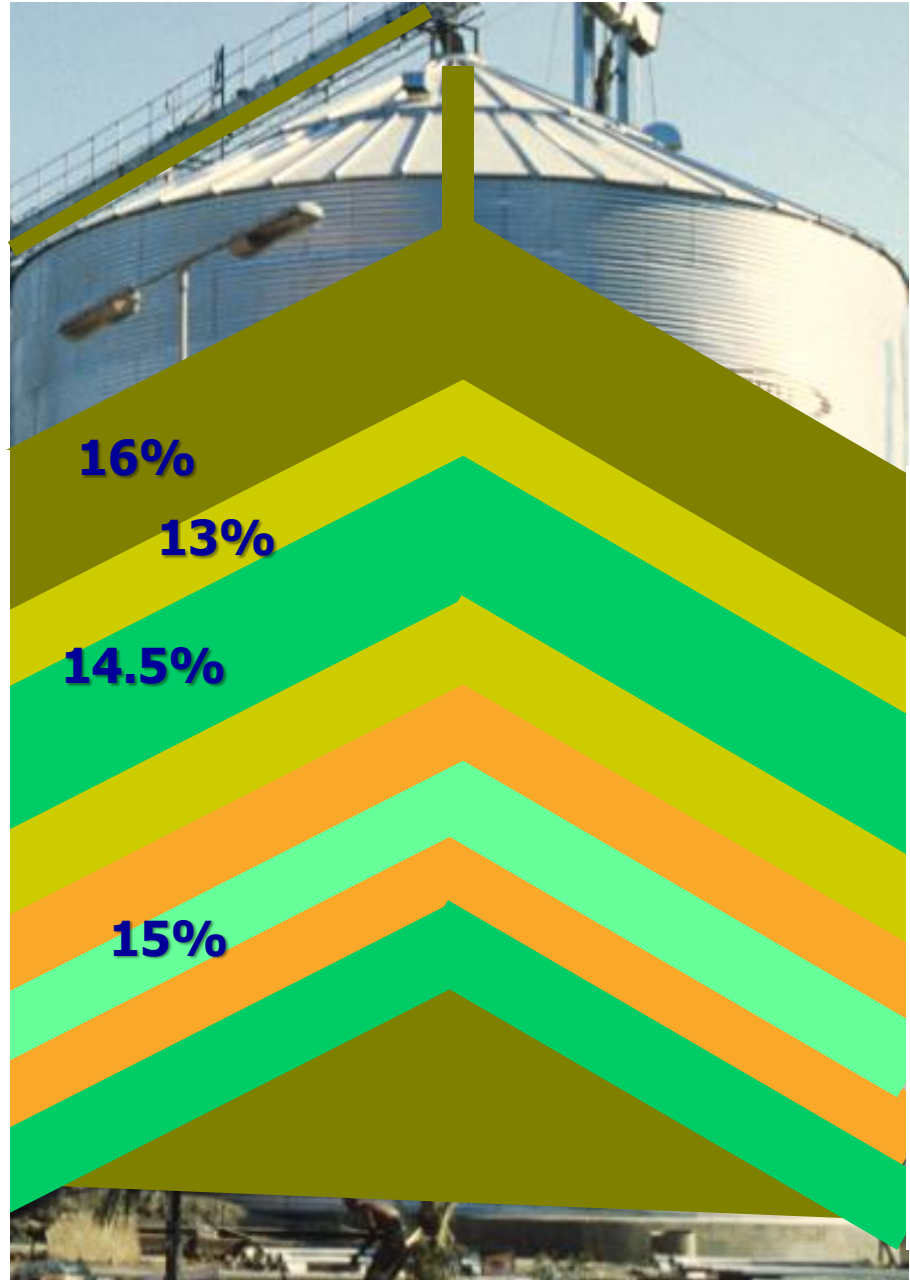
FACTORS THAT AFFECT GRAIN STORAGE



9. MOISTURE CONTENT DIFFERENCES

- Different moisture content differences inside silo will cause early spoilage.
- Try to store grain with same moisture content.

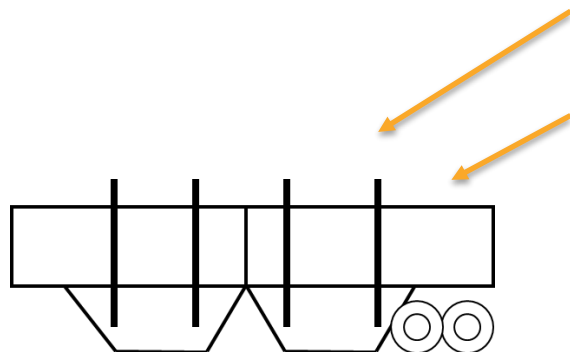
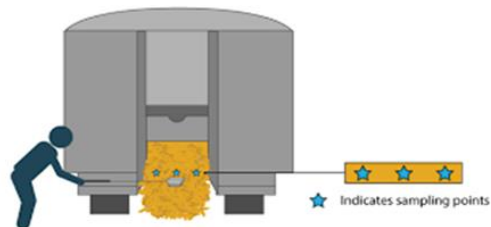
Source of slide: Dr. Carl Reed



Steps to Preserve Grain and Feed Ingredients in Feed Mills in Tropical Weather Conditions

First Step: Good Sampling Procedure and Analysis

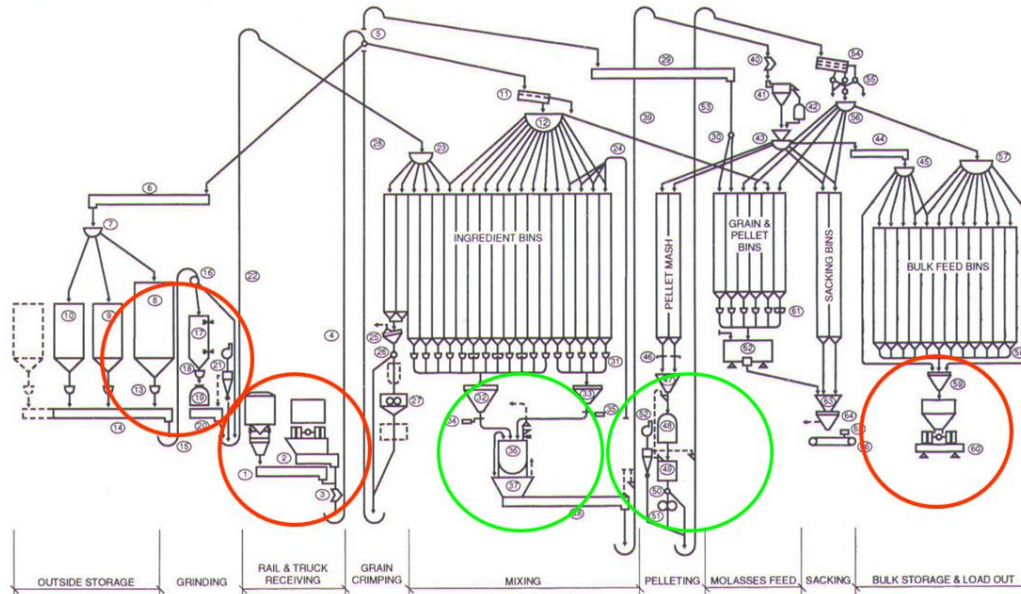
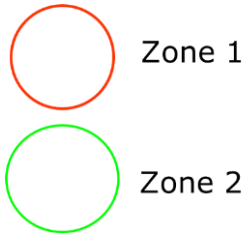
- Inspection at receiving – composite and representative sample
- Quantify feed ingredient quality (composition, moisture content, pest infestation) and contaminants (mycotoxins)
- Part of a QA/QC program - SOPs



Second Step: Understand your Facility

- Development of a Sanitation Program

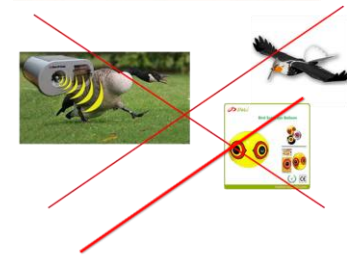
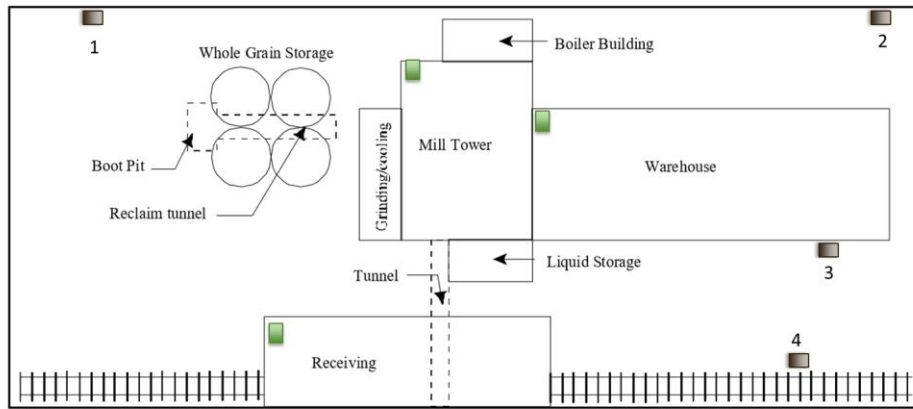
Use diagram of plant to determine ranking of cleaning areas:



Month						
1	2	3	4	5	6	7
8	9	10	11 Mixer Cleaning	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Second Step: Understand your Facility

- Development of an Integrated Pest Management Program (IPM) to control insects, rodents, birds, etc



External rodent traps



Internal rodent traps



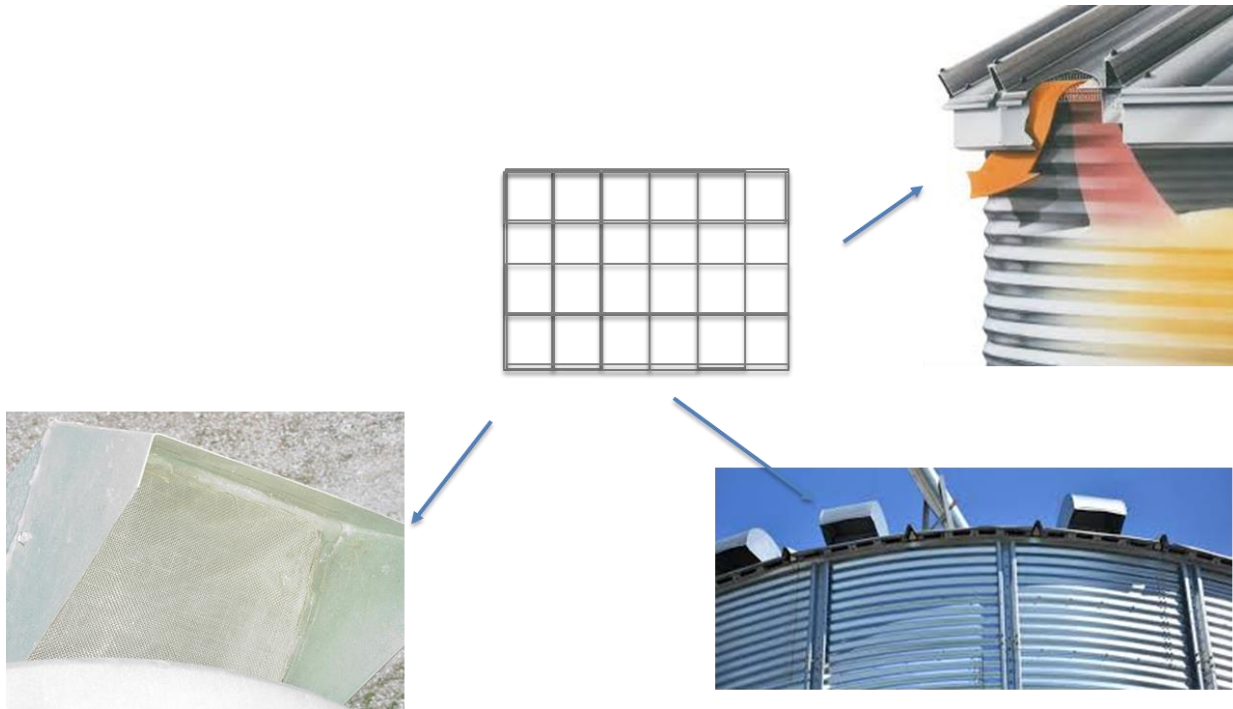
Second Step: Understand Your Facility

- Application of physical barriers (flat storage)



Second Step: Understand Your Facility

- **Application of physical barriers (silos)**



Third Step: Grain Cleaning Before Storage

- Removal of BCFM helps improve quality for storage and processing.

Parameter	Whole Corn	BCFM	Dust
Moisture Content (%)	13.85 ± 0.04	13.74 ± 0.07	13.47 ± 0.06
Protein (%)	6.87 ± 0.04	6.73 ± 0.11	6.66 ± 0.10
Ash (%)	1.11 ± 0.02	0.76 ± 0.05	0.81 ± 0.04
Fat (%)	2.81 ± 0.09	1.06 ± 0.14	1.03 ± 0.10
Fiber (%)	1.82 ± 0.05	1.82 ± 0.05	1.72 ± 0.07
Aflatoxin (ppb)	ND	ND	ND
Zearalenone (ppb)	66 ¹	119.6 ± 52	560.8 ± 225
T-2 (ppb)	ND	ND	23 ¹
Vomitoxin (ppm)	0.37 ± 0.05	1.20 ± 0.2	3.62 ± 0.5
Fumonisin (ppm)	0.25 ± 0.01	1.14 ± 0.17	2.44 ± 0.58
Mold (cfu/g)	100 ± 31	2,620 ± 1,270	48,760 ± 35,855



Rotating sieves



Gravity cleaners



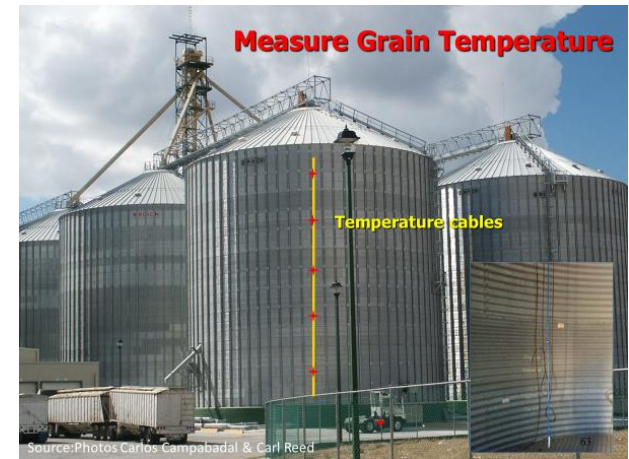
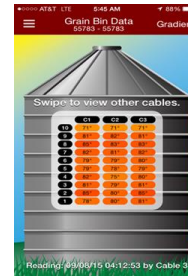
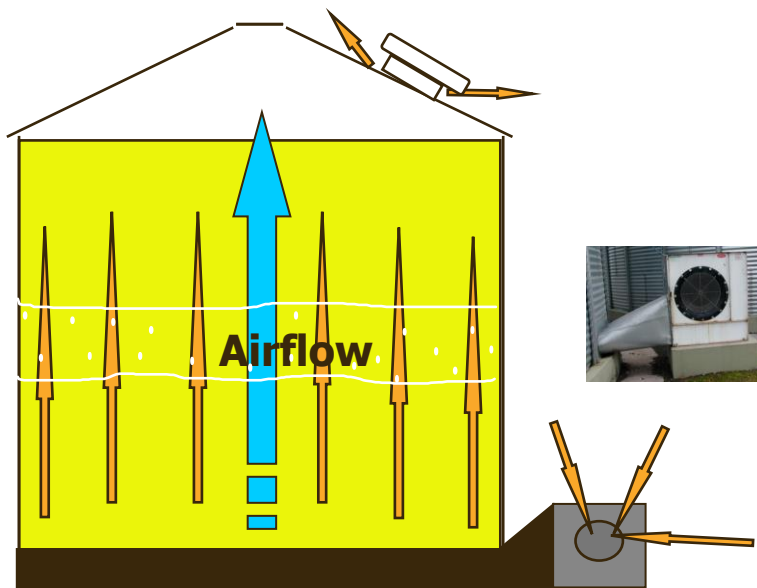
Sifters



Scalper

Fourth Step: Apply Grain Storage Practices

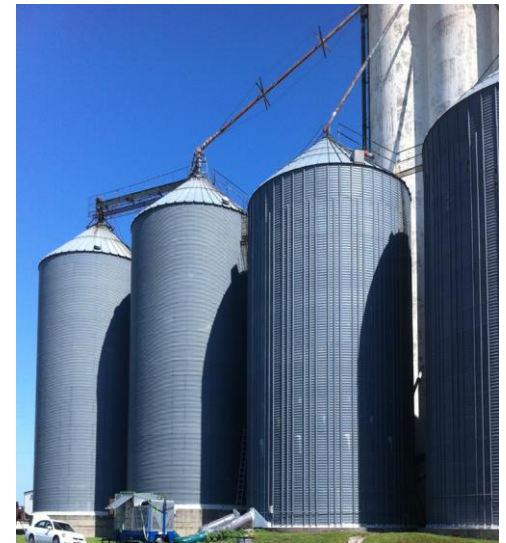
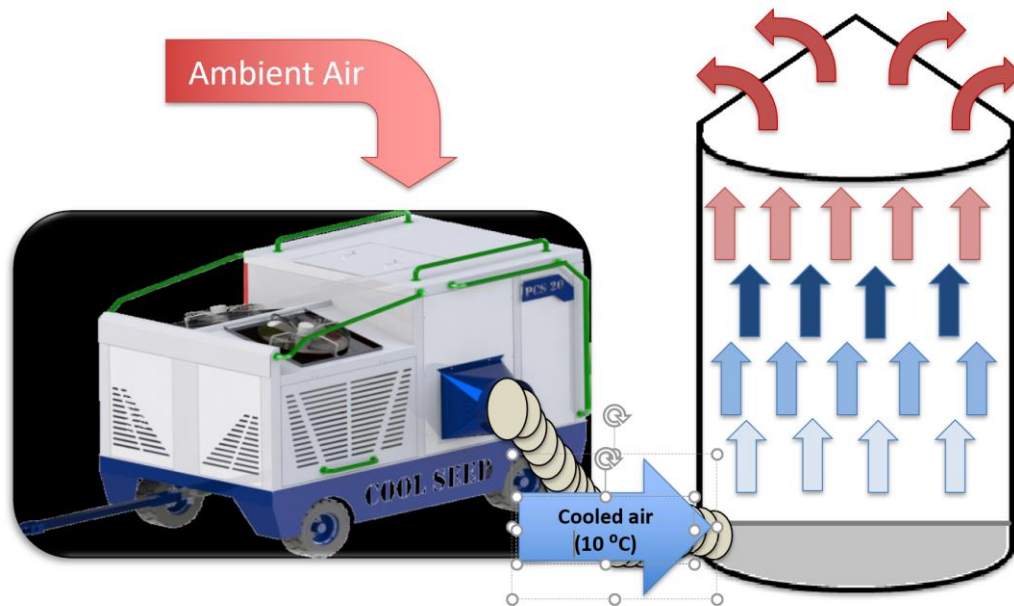
- Apply aeration when possible
 - Temperature difference of 5°C
 - Temperature lower than 30-32°C & 80% RH



Date	Temperature in each of the 16 sensors (Celsius °)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Fondo										Arriba					
26/06/14	31	29	27	26	24	23	22	21	20	19	19	18	16	16	16	20
30/06/14	32	32	32	32	31	28	26	24	23	21	20	20	19	17	16	21
07/07/14	30	31	32	34	37	32	31	26	24	22	21	20	18	17	16	21
14/07/14	28	29	30	32	34	36	39	38	36	30	24	22	21	21	27	27
25/07/14	22	23	23	25	26	27	28	29	28	29	31	32	31	29	27	28
04/08/14	26	26	26	26	28	29	31	31	30	31	32	39	26	26	26	26
11/08/14	27	26	26	26	27	28	30	34	33	31	34	39	29	28	28	28

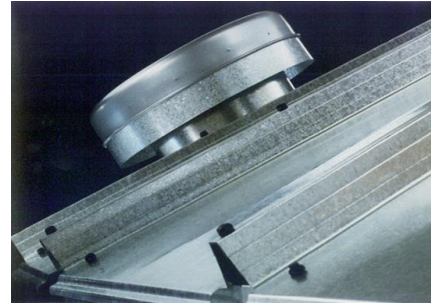
Fourth Step: Apply Grain Storage Practices

- **If aeration cannot be done:**
- Reduction of grain and oilseed temperature using grain chilling



Fourth Step: Apply Grain Storage Practices

- **If aeration cannot be done:**
 - Remove condensation with roof fans



- Block aeration fan to avoid pests' entrance



Fourth Step: Apply Grain Storage Practices

- Reduction of temperature in SBM and FFSBM in flat storage (warehouses)



Fourth Step: Apply Grain Storage Practices

- Application of mold inhibitor
 - Controls growth of molds that deteriorate quality
 - Controls growth of molds that can produce mycotoxin (*Aspergillus Flavus* & *Glacus*)



Molds That Produce Mycotoxins in Grain

Mycotoxin	Mold	Growing Conditions	Limit of Moisture Content	Where it grows
Aflatoxins	Aspergillus flavus & parasiticus	15 & 45C Optimum: 37 to 39C RH 82%	16-16.5%	Field and Storage
Ochratoxins	Penicillium/ Asp Glaucus	5 & 45C Optimum 30 to 35C RH 73%	14-14.5%	Field and Storage (wet and cold)
T-2 & DON (Vomitoxin)	Fusarium spp	4 & 36C RH 91%	19-20%	Field
Fumonisin	Fusarium verticilliodes	4 & 36C RH 91%	19-20%	Field
Zeralenone	Fusarium spp.	4 & 36C RH 91%	19-20%	Field



Seed

Growing & Harvest

Storage and Processing

Feeding

Fourth Step: Apply Grain Storage Practices

- Application of mycotoxin binders if necessary
 - Use if mycotoxins are present (no more than 2% on formulation)
 - Don't work for all mycotoxins
 - Can affect nutrient absorption
 - Types
 - Aluminosilicates (Zeolites, bentonites, montmorillonite)
 - Activated charcoal
 - Diatomaceous earth

Bentonite Clay



Zeolite



Montmorillonite



Activated
Charcoal



Diatomaceous Earth



Fourth Step: Apply Grain Storage Practices

- Rotation of inventories (bag and in bulk)



First in is First Out (FIFO)

Fourth Step: Apply Grain Storage Practices

- Application of insecticide (grain protectants)



Internal



External



Application mixed with the soybeans (grain protectants)



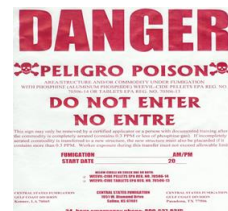
Fourth Step: Apply Grain Storage Practices

- **Fumigation**

1. Use the right dose
2. Follow manual instructions
3. Seal all structure to be fumigated



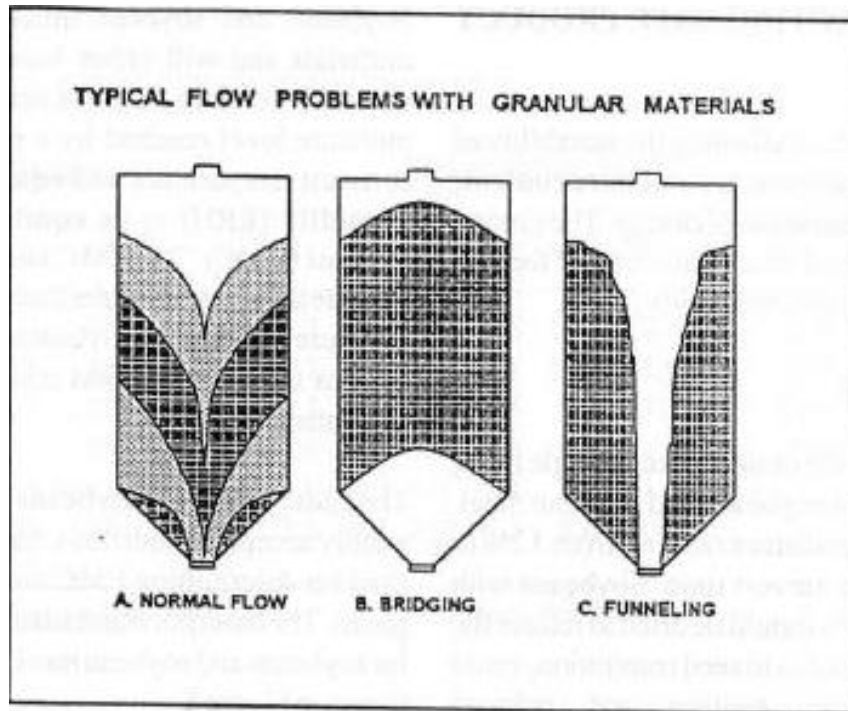
Complex



In Summary To Preserve Grain in Tropical Locations:

- Grain cleaning to avoid BGMF accumulation
- Grain movement through bins
- Grain temperature measurement
- Application of aeration when it is possible
- Use as fast as possible
- Use of mold inhibitor & mycotoxin binder when needed
- Fumigate when needed

Other Things To Understand When Storing Soy Products



Acasio, 1997. Handling and Storage of Soybean and Soybean Meal, ASA Publications

Use of vibrators



Correct angle in bottom

Evaluation Of Storage Practices

Evaluation of IPM and Quality Control & Assurance Program

- Key Performance Indicators
- Costs/Benefit
- Value of Origin

Date Validation Conducted	_____			
Conducted By	_____			
Finished Feed Name	_____			
Formula Number	_____			
Assay from Drug	_____			
Expected Level	_____			
Sample No.	%Protein	%Fat	%Calcium	Drug Level
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____
5.	_____	_____	_____	_____
6.	_____	_____	_____	_____
7.	_____	_____	_____	_____
8.	_____	_____	_____	_____
9.	_____	_____	_____	_____
10.	_____	_____	_____	_____
Average	_____	_____	_____	_____
Coefficient of Variation	_____			%
*Attach copies of formula and batch run report to this form.				

IMPORTANT!!!

TAKE HOME MESSAGE:

Grain quality **NEVER**
improves during
storage, but it can be
maintained!

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Phone +1.217.721.1025

Thank you!

